



EFFECT OF A NUCLEAR DETONATION IN A U.S. CITY

Subject: Science | Current: 2009 | Grade: 9-12

Day: 4 of 4

1 Purpose

To have the student become aware of computer models for assessing the effects of WMDs (specifically, a nuclear detonation) over large geographic areas.

2 Duration

50 min.

3 Objectives

Students should be able to:

- Understand the value of computer models for making predictions of weapons effects.
- Appreciate the extreme hazard of nuclear weapons as a weapon of mass destruction.
- Understand how weather and geographical factors (e.g., land contours) affect the migration of radioactive fallout.

4 Standards Addressed

Effect of a Nuclear Detonation in a U.S. City: Web-based model

EARTH SPACE SCIENCE

Understand and describe the origin, life cycle, behavior, and prediction of weather systems. (Core Standard)

ES.1.15

Investigate the causes of severe weather and propose appropriate safety measures that can be taken in the event of severe weather. (Core Standard)

ES.1.16

AGRICULTURE EDUCATION/NATURAL RESOURCE MANAGEMENT

Students shall exhibit safety procedures and be prepared to handle minor emergency situations that may arise in an outdoor location.

NRM.T

Describe the value of layering when dressing for cold weather, and the proper clothing needed and appropriate behavior for protection from rain, snow and extreme heat and cold.

NRM.T.5



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Students shall examine the basic components of weather systems and their effects on resource management and rural recreation.

NRM.U

Distinguish between weather and climate.

NRM.U.1

WORLD GEOGRAPHY

Students will acquire a framework for thinking geographically about places and regions. They will identify the physical and human characteristics of places and regions. They will understand that people create regions to interpret Earth's complexity, and how culture and experience influence people's perception of places and regions.

WG.2

Name and locate the world's continents, major bodies of water, major mountain ranges, major river systems, all countries and major cities.

WG.2.1

Give examples of how and why places and regions change or do not change over time.

WG.2.2

Students will acquire a framework for thinking geographically about Earth's physical systems. They will explain the physical processes that shape the patterns of Earth's surface and the characteristics and spatial distribution of ecosystems on Earth's surface.

WG.3

Explain and give examples of the physical processes that shape Earth's surface that result in existing landforms and identify specific places where these processes occur.

WG.3.4

Students will acquire a framework for thinking geographically about human activities that shape Earth's surface. They will examine the characteristics, distribution and migration of human populations on Earth's surface; investigate the characteristics, distribution and complexity of Earth's cultural mosaics; analyze the patterns and networks of economic interdependence on Earth's surface; examine the processes, patterns and functions of human settlement; and consider how the forces of cooperation and conflict among people influence the division and control of Earth's surface.

WG.4

Using maps, establish world patterns of population distribution, density and growth. Relate population growth rates to health statistics, food supply or measure of well-being. Explain that population patterns differ not only among countries but also among regions within a single country.

WG.4.1

Develop maps of human migration and settlement patterns at different times in history and compare them to the present.

WG.4.2



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Hypothesize about the impact of push factors and pull factors on human migration in selected regions and about changes in these factors over time.

WG.4.3

Students will acquire a framework for thinking geographically about the environment and society. They will analyze ways in which humans affect and are affected by their physical environment and the changes that occur in the meaning, distribution and importance of resources.

WG.5

Identify and describe the effect of human interaction on the world's environment.

WG.5.1

Map the occurrence and describe the effects of natural hazards throughout the world and explain ways to cope with them.

WG.5.3

Analyze the possible effect of a natural disaster on the local community and devise plans to cope with a disaster so as to minimize or mitigate its effects.

WG.5.4

GEOGRAPHY AND THE HISTORY OF THE WORLD

Students will examine the physical and human geographic factors associated with examples of how humans interact with the environment, such as deforestation, natural hazards and the spread of diseases, and the regional and global consequences of these interactions.

GHW.9

Identify regional resource issues that may impede sustainability, economic expansion and/or diversification. Assess the impact of these issues on the physical and human environments of specific regions. Propose strategies for dealing with regional resources issues.

GHW.9.2

Identify and describe ways in which humans have used technology to modify the physical environment in order to settle areas in different world regions. Evaluate the impact of these technologies on the physical and human environments affected.

GHW.9.3

Distinguish and assess the human and physical factors associated with the spread of selected epidemics and/or pandemics over time and describe the impact of this diffusion on countries and regions. Propose strategies for limiting the spread of diseases.

GHW.9.4

BUSINESS, MARKETING, & INFORMATION TECHNOLOGY

Discuss a variety of organizational models

BM.5.1.1



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Using trend data and forecasting models, calculate future sales. (this goes along with using the models to make predictions)	BMTH.4.1.7
Students identify models of application	IT.5.3
Students evaluate various data modeling techniques	IT.28.2
Interpret terminology associated with data models	IT.28.2.1
Compare/contrast various data models	IT.28.2.2
Analyze data models	IT.28.2.3
Students create conceptual data models	IT.28.3
Students develop models	IT.34.4
Define scope and purpose of models	IT.34.4.1

5 Vocabulary

Effect of Nuclear Detonation in a U.S. City: Web-Based Model

- **Fallout:** Residual radioactive material following a nuclear detonation. Radioactive particulates are first released into the atmosphere, following which they will rain down on Earth. This process may take from minutes to decades.
- **Ground zero:** Precise location of a nuclear detonation.
- **Overpressure:** The increase in atmospheric pressure over normal air pressure. It is the overpressure which kills via damaging essential organs; overpressure will also destroy structures.
- **REM (Roentgen Equivalent Man):** A measure of radiation dose received by an individual. Although data varies, a single exposure in the tens of REMs is considered dangerous to health.
- **TNT:** Trinitrotoluene, a common commercial and military explosive.
- **WMD:** Weapon of mass destruction. A weapon which, when used, will cause massive damage to structures and massive injury and death. The weapons within this class include biological, chemical, radiological, nuclear, and explosive.



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- Yield: The destructive force of a nuclear detonation, measure in terms of tons of TNT. A 1-kiloton blast is equal to the destructive force of 1,000 tons of TNT; a 1-megaton blast is equivalent to 1,000,000 tons of TNT.

6 Materials

One computer with Internet access for every two students, copies of the student activity page, Supplementary Material File; examination, Supplementary Material File

7 Additional Resources

Effect of Nuclear Detonation in a U.S. City: Web-Based

- <http://www.fas.org/programs/ssp/nukes/nuclearcalculators/nuclearwpneffctcalc.html>Source:
- <http://www.fas.org/programs/ssp/nukes/effects/falloutcalc.html>
- http://www.webpal.org/d_resources/states/in.htm

8 Procedures

Effect of Nuclear Detonation in a U.S. City: Web-Based

A. Introduction

Nuclear weapons are the most powerful of all WMDs. The detonation of a nuclear device by a terrorist group would result in catastrophic physical effects including blast overpressure, thermal effects and radiation contamination, and also cause tremendous psychological impacts worldwide.

International terrorist organizations have recently made efforts to gain access to WMDs, including nuclear weapons, by attempting to recruit nuclear weapon scientists. In addition, certain nuclear nations may still pose a military threat to others.

It is essential for government officials and emergency responders to be able to gauge the potential local and long-range impacts of a nuclear detonation. This includes being able to predict both immediate and long-term (e.g. fallout) effects from detonation of such weapons.



B. Development

To the whole class, the teacher will explain that during the Cold War between the United States and the Soviet Union (late 1940s to early 1990s), the nations of the world lived with the constant threat of nuclear war. With the end of the Cold War came the hope that the nuclear arsenals stockpiled by these and other countries would eventually be dismantled. Unfortunately, however, international terrorist organizations have recently made efforts to gain access to WMDs, including nuclear weapons, by attempting to recruit nuclear weapon scientists. In addition, certain nuclear nations may still pose a military threat to others.

C. Practice- Small Groups

In groups of two, the students will be given the attached Nuclear Model.docx worksheets, only their copies will obviously not have the answers on them. They are to go to two websites and answer the questions about blast effects and the fallout calculator. When they are finished, these will be returned to the teacher.

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Effect of a Nuclear Detonation in a U.S. City: Web-based Models

(Teacher's Key)

Assessment- Students will be given this sheet, without the answers, and will turn it into the teacher

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In this activity we will use two mathematical models to assess two primary effects of a nuclear detonation in a major U.S. city: (1) initial blast damage; and (2) radioactive fallout.



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A. Blast Effects

This first model will give an idea of the effects of ground-level and low-altitude nuclear weapon detonations. The model applies to conventional nuclear weapons as well as potential terrorist attacks.

High-definition aerial maps of selected U.S. cities are provided. The size of the bomb can be chosen by selecting the weapon's yield, as measured in kilotons (KT) or megatons (MT) of TNT equivalent. There is also the option of having the bomb delivered using an automobile at ground level or using an aircraft flying at an altitude that produces the widest area of destruction.

Refer to the website:

<http://www.fas.org/programs/ssp/nukes/nuclearcalculators/nuclearwpneffctcalc.html>

Using the website answer these questions.

1. Select **Chicago** and place Ground Zero directly over downtown (click and drag the colored rings). Select **Automobile** as the delivery method. Note the yield for a **1-KT** blast and refer to the color-coding of the rings.

Red Circle: Intense heat from the explosion will likely cause widespread fires within this region.

Blue Circle: Most homes are completely destroyed and stronger commercial buildings will be severely damaged due to the high pressure blast wave in this region.

Yellow Circle: Moderate damage to buildings causing some risk to people due to flying debris is caused by the blast wave in this region.

Does the damage from a 1-KT blast extend significantly beyond downtown?

No.

2. Now change the weapon yield to 1 MT. Does the damage extend significantly beyond downtown?

Yes. Damage extends for many miles in all directions.



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3. Change the delivery method to **Aircraft**. Is there a difference in damage by the detonation?

Explain your answer.

An aircraft delivery, presumably detonating above the skyline, will do greater damage; an automobile bomb (at ground level) will be somewhat 'blocked in' by surrounding buildings and hence do less damage.

4. Would the populations of this city be protected from nuclear radiation by the presence of the structures?

The buildings would only stop certain types of radiation; other types (for example gamma radiation and neutrons) will pass through concrete.

5. What are the most common ailments associated with radiation exposure?

Cancer (many forms possible).

6. What is the yield of the largest nuclear detonation? What country was responsible for this detonation? Did it occur during wartime?

Approx. 50 MT, Soviet Union. Occurred as a test during the Cold War.

B. Fallout Calculator

A nuclear bomb has the potential to have an impact over a large area due to several factors such as wind and the size of the weapon. This model provides the distribution of fallout, by wind, from nuclear detonations of various yields. The contours depict calculated radiation doses of 300, 25, and 1 REM at 96 hours after detonation.

You may select wind speed (15, 30, or 45 miles per hour) and wind direction. You may choose from an assortment of yields ranging from 1 kiloton to 50 megatons.

Use http://www.fas.org/programs/ssp/nukes/nuclear_weapon_effects/falloutcalc.html.



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Using the above link, locate Chicago and choose the following settings:

Wind Speed: **15 mph**

Wind Direction: **SE**

Yield: **1 KT**

1. Using the following key determine the approximate amount of REMs that would affect downtown Chicago: _____ REM.

Blue Ellipse: 300 REM. At this accumulated dosage, the risk of fatalities is approximately 50% and increases drastically closer to the blast site.

Green Ellipse: 25 REM. At this range, only emergency workers and parties fully aware of the associated risks will (on a voluntary basis) be allowed to enter this region for the purpose of saving lives.

Red Ellipse: 1 REM. At this accumulated dosage, evacuation and sheltering is recommended.

2. Would any fallout extend into Indiana? Is this amount significant from a public health perspective?

3. Now change the wind speed to 45 mph. Does this affect the extent of the fallout plume into Indiana?

4. Return to a setting of 15 mph and change yield of explosion to 1 MT. Does the amount of fallout over 1 REM change significantly?

5. Change the yield to 50 MT. How does the range of fallout change? What happens with a wind speed of 45 mph?

D. Independent Practice

If time remains in class, the students can study for the next day's exam over this unit.



E. Accommodations (Differentiated Instruction)

Students who have visual, mobile or hearing impairments may need adaptive computer software to assist with using the computer and accessing the websites for information during the simulation. Students who are ELL as well as other students who may have developmental issues may need more scaffolding during the simulation to be able to complete it. This could be in the form of additional prompts for each question and a graphic organizer, perhaps a flow chart, to assist them in staying on track and managing the information.

For highly able/gifted students, you may want to make the simulation more abstract, by giving them less structured questions. You may just provide them with the scenario; let them figure out what needs to happen next, where to go for information, and so forth. Check in with them, ask some probing questions, and then give them the updates to the scenario.

F. Checking for Understanding

The activity done in class will be returned to the teacher.

G. Closure

Careers in this area include:

- Investigator, Federal Bureau of Investigation: <http://www.fbijobs.gov/11.asp>
- U.S. Coast Guard: <http://uscg.mil/top/careers.asp>

Related websites:

- Directorate for Science and Technology: http://www.dhs.gov/xabout/structure/editorial_0530.shtm
- Domestic Nuclear Detection Office: http://www.dhs.gov/xabout/structure/editorial_0766.shtm
- Federal Bureau of Investigation: www.fbi.gov
- Federal Emergency Management Agency: www.fema.gov
- U.S. Department of Homeland Security: www.dhs.gov
- U.S. Coast Guard: <http://uscg.mil>
- U.S. Immigration and Customs Enforcement: www.ice.gov

9 Evaluation

Today's activity will be graded, and tomorrow's exam will show the teacher if the students understood and retained the information taught in this unit.



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10 Teacher Reflection

----- To be completed by teacher

11 Media & Resources

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- http://www.webpal.org/d_resources/states/in.htm
- Directorate for Science and Technology:
http://www.dhs.gov/xabout/structure/editorial_0530.shtm
- Domestic Nuclear Detection Office: http://www.dhs.gov/xabout/structure/editorial_0766.shtm
- Federal Bureau of Investigation: www.fbi.gov
- Federal Emergency Management Agency: www.fema.gov
- U.S. Department of Homeland Security: www.dhs.gov
- U.S. Coast Guard: <http://uscg.mil>
- U.S. Immigration and Customs Enforcement: www.ice.gov
- Investigator, Federal Bureau of Investigation: <http://www.fbijobs.gov/11.asp>
- U.S. Coast Guard: <http://uscg.mil/top/careers.asp>